LINN

BREEDING
ANIMALS
IN & IN

AGRICULTURE
B. S.

1898

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EFFECTS OF

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T H E S I S

F o r T h e D e g r e e

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College Of Agriculture,

U-N-I-V-E-R-S-I-T-Y O-F I-L-L-I-N-O-I-S.

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F. D. Linn.

1898.

While some make arbitrary distinctions in the meaning of the terms in-breeding, inter-breeding, and in-and-inbreeding, others use them synonomously, which makes it necessary to define them in order to avoid confusion.

I have used in-breeding and in-and-inbreeding to designate the breeding together of relations without regard to the degree of relationship. Inter-breeding, from the derivation of the term, is used to signify the crossing of different varieties and is not properly applied to the mating of relations.

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The effect of in-breeding upon the immediate progeny and upon successive generations of animals is a subject which has received considerable attention from naturalists, and more from stockmen; yet it is not thoroughly understood, nor can it be until science sheds more light upon the principles of reproduction.

The literature on the subject is fragmentary and very much scattered, and I began the present study as a thesis in the hope that, by reviewing and summing up what has been written, and by collecting data from other sources, I could secure sufficient information to make possible the deduction of somewhat definite conclusions. I have corresponded with many stockmen, breeders, and

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scientific experimenters, and the following discussion involves data obtained from them. The instances which are cited have been selected because they are well authenticated, and because they show the experience various men have had with in-breeding under many and diverse circumstances.

The work of the breeder is largely the artificial, or extra-natural, development, by the accumulation of slight variations, of special useful characters, and, since a given variation is more likely to occur in two animals which are related than in those not connected by blood ties, it is often necessary, in order to fix such variation, to mate near relations, thereby decreasing the number of ancestors and securing in the progeny a uniformity of hereditary tendencies and increasing their transmissive power. If the selection for a certain character or quality be maintained through several generations, and mating of relations be continued, the character may become firmly fixed, or dominant, and the animal become prepotent in the transmission of such character.

It is, then, the hope of fixing characters and of securing prepotency that in most cases induces breeders to practice in-breeding.

The convenience of practicing in-breeding in the formation of a breed is too obvious to require discussion, and it is suffic-

ient to say that there are many instances which show that strong productive herds with notable characteristics have been developed from a few ancestors by repeated mating of those closely connected by blood ties. Ex-Gov. Hoard of Wisconsin, describes a herd of cattle bred on an island in Lake Winnipiseogee, New Hampshire, which were descended from but two animals, Guernseys, and which he says was as fine lookingg a dairy herd as he ever saw. They had been bred about twenty years with no out-cross. Many superior individuals had been produced, and, as a whole, the herd was productive, both at the pail and as breeders.

Mr. Cole, Solsville, N. Y., has a herd of cattle that he calls "Holderness", which are descended from a single cow and her bull calf. "Mr. Cole has for twenty years bred his herd incestuously in-and-in in almost every degree of consanguinity, never using a bull from any herd but his own. The result is that he now has a herd of 22 or 23 cows, quite uniform in appearance, and quality, preserving the vigor and stamina of his original cow. He finds ready sale for every animal that he has to spare". (Country Gentleman", Aug. 14, 1879.) "The main secret of Mr. Cole's success in his practice of in-breeding has been in the selection of the bull calves to be used in his herd. The rule has been to choose one of the most perfect form, showing the amplest development of

the qualities to be propagated, and from a dam of unquestionable excellence in productiveness, added to which she must be of good form, robust and healthy in constitution. No diseases, chronic or otherwise, have yet been developed in the herd". ("Country Gentleman", Sept. 11, 1879.)

It is held by many that in-breeding reduces the size and vigor of animals, and that animals which have been in-bred are more susceptible to disease than are animals which have been out-bred. On this Mr. Darwin says: "That any evil directly follows from the closest in-breeding has been denied by many persons; but rarely by any practical breeder; and never, so far as I know, by any one who has largely bred animals which propagate their kind quickly. Many physiologists attribute the evil exclusively to the combination and consequent increase of morbid tendencies common to both parents; and that this is an active cause of mischief there can be no doubt. Close breeding, on the other hand, often induces sterility and this indicates something quite distinct from the augmentation of morbid tendencies common to both parents". (Darwin's "Animals and Plants Under Domestication", vol. II, p 14.)

With respect to pigs Mr. Darwin says: "There is more unanimity among breeders on the evil effects of close in-breeding than, perhaps, any other of the large animals. Mr. Wright, an English

breeder, crossed the same boar with the daughter, grand-daughter, great-grand-daughter, and so on for seven generations (which would be the closest form of in-breeding except had the union been between brother and sister). The result was that in many instances the offspring failed to breed; in others they produced but few that lived; and many of the latter were idiotic without sense even to suck. The best sow in external appearances produced during the whole seven generations was one in the last stage of descent, but the litter consisted of but this one sow. She would not breed to her sire, yet bred at the first trial to a stranger in blood. So that in Mr. Wright's case, long continued and extremely close breeding did not affect the external form or merit of the young; but with many of them the general constitution and mental powers and especially the reproductive functions were seriously affected". (Darwin's "Animals and Plants Under Domestication", vol II, p.100.)

While it is impossible to state absolutely with regard to this instance whether the defects were due to some principal inherent in the nature of in-breeding, or whether they resulted merely as a summation of weaknesses, it may be said that the latter view is tenable, since other breeders have experienced similar difficulties in out-breeding where selection has been continually for some single character or quality. That sterility should result as

a summation of weaknesses is no less probable than that other defects should accumulate. In fact a large per centage of breeding animals are in some degree infertile.

Regarding the effects of in-breeding swine, Mr. Thomas Sharpless, West Chester, Pa., says: "Once, to put a fancy head on an extra body, I bred a son to his mother, and on the offspring crossed the original sire, and produced the finest hog I ever owned; and further, I breed without much regard to relationship, selecting the points I wish to keep and perpetuate".

The herd-books and registers of the various breeds of domestic animals contain abundant evidence showing that this has been the practice generally of the great improvers. I have made a careful study of the pedigrees of a great many animals, especially in the Shorthorn, Jersey, and Holstein-Friesian herd books, and the animals whose pedigrees are shown in the diagrams were selected because their histories are well known and because they show the methods of recent improvers, as well as those of older ones.

Diagram II, pedigree of Grazier (1035), indicates the closeness with which the early Shorthorn breeders mated their animals. Twenty-nine sixty-fourths of Grazier's blood was that of Favorite (252), and five-eighths that of Midas (435) who was Grazier's sire and also the sire of his grand-dam. Midas was also in-bred, being

the offspring of half-brother and sister. Grazier was a celebrated animal. "He was used in the herds of the Earl of Carlisle, Lord Feversham, Sir John Johnstone, Mr. Wm. Smith, and Mr. Slater. He died when 14 years of age". (Miles, "Stock Breeding".)

Few men have done as much to improve the Shorthorns as the Colling Brothers. The pedigree of Favorite (252), Diagram II, illustrates their method of breeding. Favorite was got by Bolingbroke and out of Phoenix; so that Favorite was the offspring of brother and sister on the sire's side, and of still closer breeding on the side of the dam, as the dam of Phoenix was the cow Favorite and the grand-dam of Bolingbroke was also Favorite. "To Favorite trace, in one line or another, almost every Shorthorn family of any ancientness of lineage; indeed there are few Shorthorns that do not show in some line a cross to this old bull. He lived long and was used widely. His great vigor and remarkable prepotency left a wonderful stamp". (Warfield's "Cattle Breeding", p.149.)

It should also be noted that Favorite, though closely in-bred, was crossed with his dam and got Young Phoenix, with which he was again crossed, the result this time being Comet (155). Comet was the founder of the Duchess family, and "a bull individually more admired than any other one of his day" ("Allen's Shorthorn History", p. 58).

Mr. Bates, who bred the Duchess and other families of Shorthorns, practiced in-breeding closely, especially during the earlier period of his work. "For thirteen years he bred most closely in-and-in; but during the next seventeen years he thrice infused fresh blood into his herd" (Darwin's "Animals and Plants Under Domestication", vol. II, p. 96).

See Diagram I, pedigree of 8th Duchess of Geneva, who sold for $40,600 at New York Mills sale. Duchess I was got by Comet (155) and was composed largely of Favorite's blood. Duchess 2nd and Duchess 3rd were by Ketton (709), Duchess 4th and Duchess 5th by Ketton 2nd (710), and Duchess 6th by Ketton 3rd (349). Here fresh blood was introduced through Marske (418), who got Duchess 7th, 8th, and 9th. Later Belvidere (1706) was used in several instances. Belvidere crossed with Duchess 32nd got Short Tail (261) and here the Matchem Cow was introduced, who crossed with Short Tail produced Oxford 2nd. This was a marked departure from previous methods and infused the later Duchesses with a strain of foreign blood. It is impossible to say with certainty what induced Bates to make these out crosses, though various authors explain them on the ground that his animals had greatly deteriorated by in-breeding. "With the production of Duchess 32nd Mr. Bates halted, and wisely. From the possession of his Duchess 1st in 1810, for a

period of 21 years, we find but 31 of her female descendants recorded in the herd book. There were, meantime, sundry bulls dropped from them, but mostly sold to other breeders, excepting those he had used in breeding. The simple fact was the Duchess cows, as a whole, had not been prolific or constant breeders, through abortion or other causes, and whenever they passed a year or two without breeding he fed off and slaughtered them" (Allen's "Shorthorn History," p. 126). Concerning the year 1831, at which time Duchess 32nd, the cow with which Belvidere was first crossed, was calved, it is said, "28 calves of that year died solely from lack of constitution" (Darwin's "Plants and Animals Under Domestication, vol. II, p. 97).

A study of Jersey herd books shows that, while incest has been practiced in numerous families, necessarily in the early development of the breed, many individuals noted for quality and productiveness, have been produced entirely by out breeding.

The pedigree of Mary Maiden 64944, Diagram 3, shows her ancestors to have been of mixed breeding, except in the fifth, sixth, and seventh generations back, in one strain. In the seventh, Comet was put to Theresa and got Lady Theresa to which he was put, the product this time being Bismark, who in turn was put to Lady Theresa and got Laura Lee. Mary Maiden is considered a very superior

animal, and at the World's Fair took sweepstakes in 15 day butter test; second in net profit cheese test for 15 days; second in 30 day butter test, making 66.695 lbs.; first in first fifteen days of all three tests for cheese 15 days; butter 90 days, and butter 30 days.

Mr. Dauncey, who originated the famous Stoke Pogis family of Jerseys, bred very closely. Ex-Gov.Hoard says of him: "He so managed as to increase size of bone, quality of hair, and vigor of constitution".

Numerous other instances similar to these might be quoted from Jersey breeding, as well as from the other breeds of cattle, however, enough are cited to show that, while many animals of the cattle kind have suffered through in-breeding, it is not essential to the practice that loss of size or any other degeneracy should result.

Prominent breeds of sheep exhibit instances of breeding equally as close as do those of cattle. "The Messrs. Brown, during 50 years, have never infused fresh blood into their excellent herd of Leicesters, and in France the Naz flock has been bred for 60 years without the introduction of a single strange ram" (Darwin's "Animals and Plants Under Domestication", vol. II, p. 98).

"A flock of Mauchamp Merinos originated in 1828 by the birth

of a single silky-wooled ram in the flock of M. Graux. The animals were necessarily in-bred and one imperfection after another was eliminated by selection till the fleece became all that could be desired, and the variety today is considered one of the best formed and most easily fattened" ("Country Gentleman", Sept. 6, 1881).

While the results obtained by experimenters with the smaller animals and with fowls are conflicting, each experiment has its value; and the following will serve to indicate the character of the work that has been done along this line. Prof. Mills, Montreal, conducted numerous experiments with pigeons, and says: "My results were so extraordinary as to be amusing. I obtained the most grotesque forms, having every shade of combination in the oddest way".

"Mr. Brent tried to raise a breed of trumpeters, by crossing a common pigeon, and re-crossing the daughter, grand-daughter, and great-grand-daughter with the same male trumpeter, until he obtained a bird with 15/16 of trumpeter's blood; but here the experiment failed, for breeding so close stopped reproduction" (Darwin's "Animals and Plants Under Domestication", vol. II, p. 106. This of course would be very close breeding, and definite conclusions seem obvious. On the other hand: "A gentleman in Ireland

got one pair of trumpeter pigeons and put them in a large loft alone. He kept them there 15 years, breeding and producing without once adding fresh blood; only, when they got too numerous, killing them off. The produce are as strong birds and as healthy as could be desired" (Wright's "Book of Poultry", p. 295).

Dr. J. D. Caton, American Naturalist, April, 1887, gives extended observations which he has made on the effect of in-breeding wild turkeys. He once put a cock and four hens on Santa Barbara Island, situated in the Pacific Ocean, and having an area of about 300 sq. mi., where they were allowed to multiply with no enemies to contend with except a small fox. In a few years the birds were observed to have diminished very much in size, and ten years after their introduction it was impossible to find a cock that would weigh over 6 pounds, which was less than one third of the weight of the original cock, or of those of the first and second generations. There seemed to be no deterioration among the birds except in size, as they were at all times prolific, strong and vigorous. Their food was abundant. While it is impossible to definitely assign a cause for the great decrease in size among these birds from all the facts known, it is not unlikely that in-breeding had its effect.

Numerous instances might be cited showing the experience of

practical poultry breeders with in-breeding, however, the results would be found similar to those given.

The following paragraphs are translated from the Biological Centralblatt, vol. 11:

One of the most carefully conducted and conclusive experiments that has yet been conducted with in-breeding is that by Prof. Ritzema Bos, a German, who in-bred rats. The experiment was begun in 1886 and extended over a period of six years, during which thirty generations, comprising several thousand rats, were produced. Prof. Bos selected as material for the experiment seven females, all from one litter, and a male not related to the females. The original male died after two unions, and as no strange blood was introduced the breeding was necessarily very close.

Table Showing Average Number at a Birth During the Various Years.

1887.	1888.	1889.	1890.	1891.	1892.
7 1/2	7 1/7	7 11/17	6 21/36	4 7/12	3 1/5

It will be noticed that while the number gradually decreased during the first four years (during the first twenty generations), it decreased very greatly in the following ten generations.

Table Showing per cent. of Unions Which Produced No Results.

1887.	1888.	1889.	1890.	1891.	1892.
0	2.63	5.55	17.39	50	41.18

Evidently the number of unproductive unions increased very rapidly during the later years of the experiment.

More of the young died soon after birth during the latter part of the experiment, as shown by the following table, which is made to include those which died within four weeks after birth expressed in per cent. of total number born.

1887.	1888.	1889.	1890.	1891.	1892.
3.9	4.4	5	8.7	36.4	45.5

It should also be noticed in the above tables that the year 1891, which shows such a strong and sudden increase in number of early deaths, shows a corresponding increase in number of fruitless copulations.

The experiment also gave much worse results when brother and sister were mated than when the union was between father and daughter or mother and son.

	% of births in which all were living.	Only part living.	All died later.	Fruitless.
Between brother and sister.	2.28	9	31.3	36.4
Between parent and offspring.	64.3	0	14.3	21.4

In some cases offspring of different litters but of the same parents were mated. The progeny of such unions did not differ appreciably from the progeny of parents from the same litter.

It was also noted that brother and sister which proved fruitless together were also generally infertile with other members of the herd, though the opposite occurred in some cases.

The maximum weight of the males in 1886, as well as in 1891, was 300 grams. In 1893 a few attained a weight of 275 grams, but most of the males of that year did not weigh more than 240 grams.

The general health of the rats throughout the entire experiment was good. Twelve were attacked by a disease which lamed the hinder part of the body, during the last year, however this would be a small number in comparison with the total number bred. There were three affected with "grumen star", a disease peculiar to rats.

These experiments, as well as the experience of practical

breeders, and the records of animals whose pedigrees may be studied, indicate that the character of the effects of in-breeding upon progeny varies greatly at different times and under different circumstances. In some cases, animals bred in-and-in for several successive generations have increased in size and improved in quality with no loss of vigor, while other animals by the same methods of breeding have deteriorated rapidly, especially in reproductive powers.

In Prof. Bos' experiment it is pretty conclusively shown that the impressment on the progeny of any character common to the two parents becomes stronger as the parents are more closely in-bred. It is also shown that the degree of impressment depends greatly on the relationship existing between the parents.

No definite statement can be made concerning the causation of disease or sterility by in-breeding: however, as indicated in the foregoing, in-breeding has many times been long and continuously practiced without the appearance of either of these defects, and it seems probable that such practice does not create characters but only enhances them.

Impairment of the procreative functions occurs more frequently among cattle bred for carcass than among the dairy breeds, a fact

which strengthens the belief that excessive feeding injures the reproductive organs in all classes of animals and often causes sterility. If even a tendency toward sterility be once created in this way, it might, by in-breeding, soon result in complete barrenness.

Since in-breeding tends to cancel differences and strengthen likenesses, it induces convergency of character and reduces the animal's power of variation. It is, however, impossible to state what will be the ultimate effect upon the type of such convergence. Prof. Bos noted that as breeding among his rats became closer the births were confined to certain months, and he concluded that through in-breeding animals become more dependant upon their environment.

Obviously if desired qualities are strengthened by in-breeding weaknesses may be also intensified, and, in consideration of the effects, full allowance must be made for th is undesirable action of heredity before any inherent evil can be charged to in-breeding.

The three particulars in which animals are said to suffer from in-breeding are size, vigor, and fertility. With the exception of vigor in some species, these are characters which have been developed and strengthened in domesticated forms, and accidental reversion toward the primitive form would account for substantial

loss in any or all of these particulars.

One might think that, by careful selection, breeders would be able to guard against defects which result as a summation of cumulative weaknesses, however, characters are sometimes latent, and may be transmitted in such condition for several generations, and, while they are in this way hidden for a time, they may develop unexpectedly when certain combinations are made. This fact will always combine an element of uncertainty with in-breeding.

My conclusions may be briefly summed up as follows:

1.--In-breeding in itself does not improve animals.

2.--Present available evidence fails to show that there is in in-breeding any inherent principle which insures evil results.

3.--In-breeding enhances any character, bad or good, that is common to both parents.

4.--It gives prepotency in the transmission of dominant characters.

5.--It induces convergency of character.

6.--When in-breeding is practiced the power of selection is limited.

7.--Breeders have repeatedly practiced in-breeding to advantage, and many of our most celebrated animals are closely in-bred.

8.--Uncertainty involved by inability to detect latent

characters should caution against indiscriminate practice of in-and-in breeding.

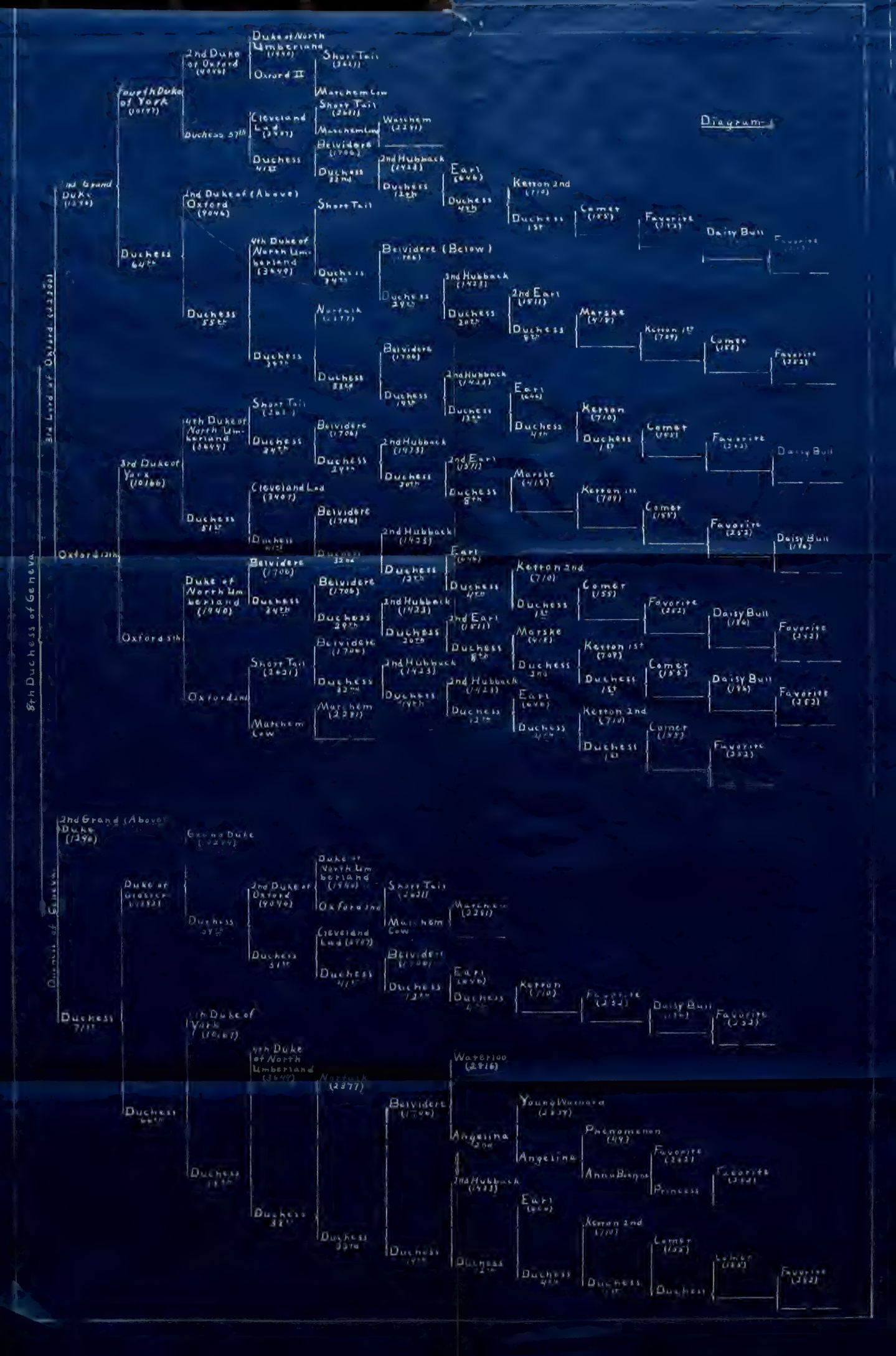
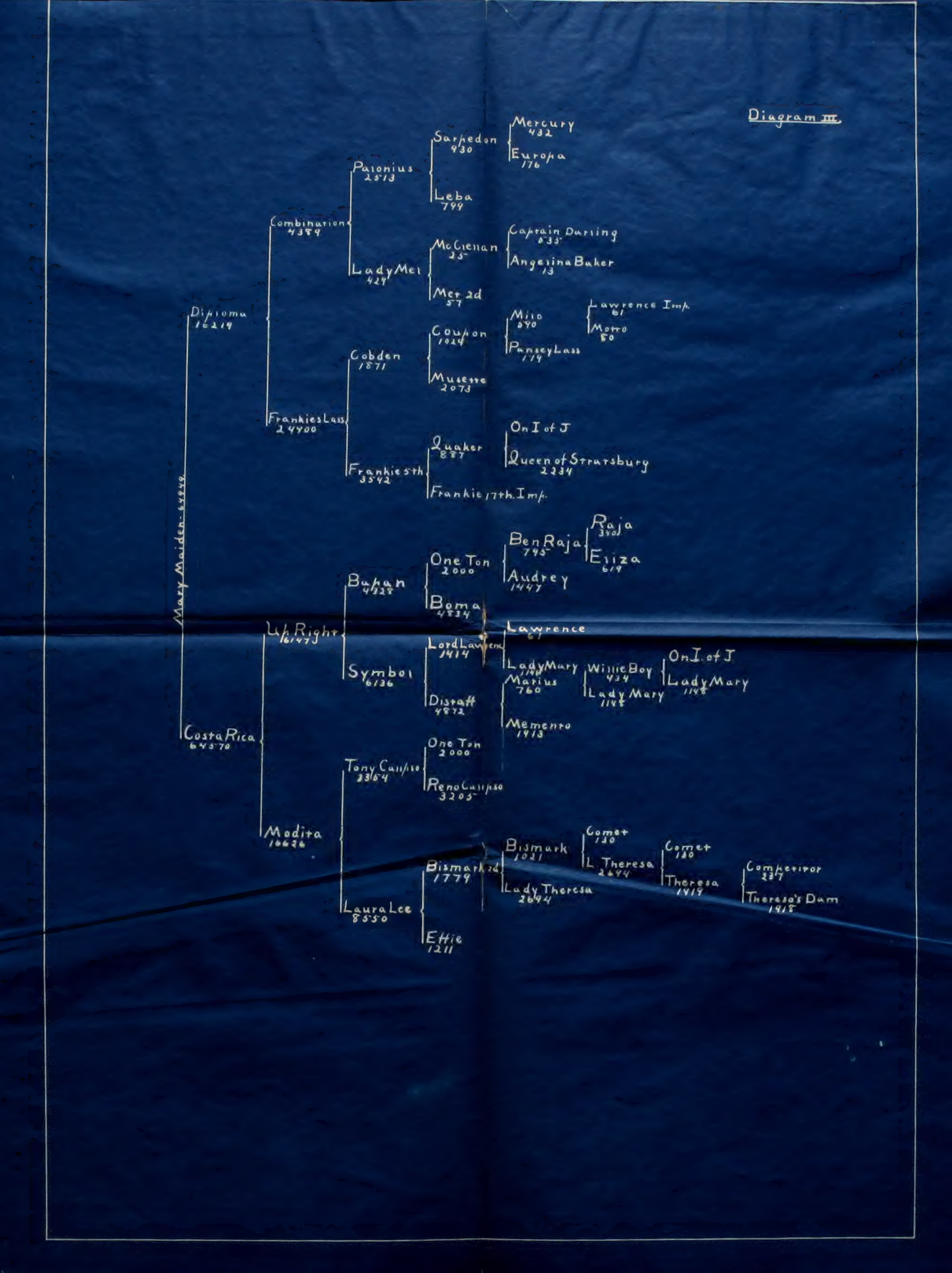


Diagram
2nd Grand Duke (1296)
Fourth Duke of York (10197)
3rd Duke of York (10166)
Duchess of Geneva
8th Duchess of Geneva
3rd Lord of Oxford (22300)
2nd Duke of Oxford (9046)
4th Duke of North Umberland (3699)
Duke of North Umberland (1940)
Duke of Gloster (12321)
Duke of Northumberland (1960)
Oxford II
Short Tail (2621)
Matchem Low
Matchem (2281)
Cleveland Lad (2907)
Belvidere (1706)
2nd Hubback (1933)
Earl (6046)
Kerton 2nd (710)
Comer (155)
Favorite (252)
Daisy Bull (196)
Marske (478)
Kerton 1st (709)
Nutwith (2877)
Waterloo (2816)
Young Warrior (2839)
Angelina
Phenomenon (49)
Annu Bunyon
Princess

Diagram
Favorite (323)
Phenomenon (471)
Midas (482)
Red Rose
Phoenix
Ben (170)
Punch (331)
Hubback (317)
Fairjame (306)
Arcot's Bull (17)
Snowden's B. (612)
Pennyman's B. (601)
Smith's Bull (602)
Jolly's Bull (337)
Banks B.
Broken Horn (95)
Barker's B. (52)
Grey Leg
Comet (177)
Adonis (61)
Beauty
Marske (477)
Miss Washington
Washington (677)
Alcot's B (19)
Smith's B. (602)
Jolly's B. (337)
Porch
Punch (331)

Diagram III.


Mary Maiden 5458
Diploma 16214
Costa Rica 6450
Up Right 16477
Modita 10626
Combination 4389
Frankies Lass 24400
Paronius 2513
Lady Mel 424
Cobden 1871
Frankies 4th 3342
Sarpedon 930
Leba 799
McGlenan 23
Mer 2d 57
Coupon 1024
Musette 2073
Quaker 887
Frankie 17th Imp.
Mercury 432
Europa 176
Captain Darling 835
Angelina Baker 13
Milo 890
Pansey Lass 174
On I of J
Queen of Strasburg 2234
Lawrence Imp. 61
Motto 50
Bahan 4928
Symbol 6136
One Ton 2000
Boma 4834
Lord Lawrence 1414
Disraeli 4872
Ben Raja 795
Audrey 1447
Raja 3401
Eliza 619
Lawrence 67
Lady Mary 1148
Matius 760
Memento 1913
Willie Boy 434
Lady Mary 1148
On I. of J
Lady Mary 1148
Tony Calypso 2364
Laura Lee 8550
One Ton 2000
Reno Calypso 3205
Bismark 1779
Ettie 1211
Bismark 1021
Lady Theresa 2694
Comet 180
L. Theresa 2694
Comet 180
Theresa 1419
Comprevisor 237
Theresa's Dam 1918

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